THE CONTROL AND DISTRIBUTION OF OVERHEAD EXPENSES.

Paper presented to the Institution, Glasgow Section, by L. A. Wight, A.C.W.A.

THE subject which has been chosen for my paper this evening is of prime importance to both the engineer and accountant. I shall commence by stating that no costing system, no matter how efficiently organised, will produce the desired results unless the necessary statistical information is presented in a manner which will convey clearly the vital facts to those executives who are responsible for production as well as administration. A system of costing may possess all the essential qualities from an accounting point of view, but may be lacking in the ability to present information to those not acquainted with accounting terms and procedure. As production engineers, I feel sure that you will agree with me on this point. In view of this, I have eliminated, wherever possible, throughout this paper any reference to accounting technique. Cost accounting after all is only a means to an end, and that end undoubtedly is the efficient control of production. Being engaged on the production or technical side of industry, you rightly wish to know in what manner the costing department within your organisation can assist you towards this objective.

It would be correct to say that in the past in many organisations the works cost accountant did not realise the necessity of applying costing technique to the existing production problems. The desired co-ordination was, therefore, lacking and cost control difficult to obtain. Such conditions to-day, however, are happily the exception rather than the rule. The cost department in an establishment to-day must represent an integral part of the organisation, and, as such, depends on receiving a full measure of support from both the technical and administrative sides of the business, in order that its services may be efficiently utilised. We realise that interchange of opinions and ideas is invaluable, and for this reason I feel sure that I personally shall benefit from what I hope will prove to be an interesting discussion after the lecture.

Cost of production, as you all know, is made up of three distinct elements : material, labour, and overhead expenses. Whilst methods of accounting for material and labour will vary with different trades and works conditions, it is safe to say that, in most cases, it is

February 21st, 1935 (Vol. XIV, No. 6, June, 1935).

possible to measure accurately the total cost of labour and material entering into a given contract, job, or process. Quite a different and much more involved problem, however, is presented, when we seek to obtain an accurate measurement of overhead expense per unit of production. Many firms, I feel sure, do not give the necessary attention to the problem of controlling the overhead costs. The importance of this aspect of cost accounting will be appreciated when I state that, in many of our industries, the overhead expenditure per unit of production is now actually in excess of, or at least equal to, the basic cost of direct labour and material. This has been brought about due to the rapid introduction of mechanised methods of manufacture in recent years. Direct or productive labour per unit of output has been reduced, but a more than corresponding increase in overhead expense is apparent. We are, therefore, presented with a new problem which requires to be tackled in the light of present-day conditions. The use of labour and material comes more directly under the control of departmental responsibility, but overhead expenditure is not so easily controlled.

Classification of Overheads.

A certain amount of confusion exists as to what expenditure can rightly be termed overhead. For the sake of clarity, therefore, I have grouped the various expenses into the following main headings :

Plant Expense.—Under this category the most important items are : depreciation, and repairs and maintenance. In addition, there are such expenses as motive power, taxes, insurances, etc.

Building Expense.—Under this heading it is convenient to associate all the expenditure appertaining to the provision and maintenance of buildings. The most important items are : rent (if the property is not owned), depreciation, taxes, repairs and maintenance, lighting, insurance, fire precautions, etc.

Works Management and Supervision.—This will embrace salaries of works manager and assistant, plant superintendent, foremen and charge-hands. In addition, there are the following expenses :

Time-keeping and Employment Department.

Research and Experiments.

Progress and Planning.

Store-keeping and Stores Control.

Canteen and Welfare.

Service Departments, such as : steam raising, compressed air, producer gas, internal transport, etc.

General Administration.—Finally, a proportion of general administrative charges should be included. In many businesses the administrative executives and general office staff are concerned equally with problems of production as well as selling, and for this reason an agreed proportion of the total administrative expenses

becomes chargeable to production, as distinct from selling. In certain cases, there will be further groups of expenses to those named, but what I have mentioned will suffice for the purpose in view.

Methods of Apportionment or Distribution.

The next problem is to determine what method or methods, can be used to accomplish an equitable distribution of these overhead expenses. Before we examine the various methods which can be used for charging these expenses to production costs, it is necessary in the first place, to decide on what basis of plant capacity such apportionment is to be made. From an examination of the nature of the overheads referred to, it will be quite apparent that certain expenses are definitely " fixed " and will not vary with production, whereas other expenses require to be placed in the category of " fluctuating or variable," in view of their tendency to increase or decrease with different plant operating levels. If we take some of the fixed expenses such as depreciation, rent, insurance, taxes, works management, etc., we must decide whether or not the objective is to recover the whole of such expenditure over less than the normal output, when such conditions prevail. The same question arises with regard to the fluctuating or variable expenses, as in most cases only a slight increase in such expenditure would be necessary in order to carry a considerably higher increase in production. Irrespective of whether rates for overhead are expressed as either a percentage on the direct wages, a rate per man-hour, or a rate per machine-hour, it is necessary to determine if such rates are to be normal, that is to say, the most economical obtainable under normal conditions. If we attempt to recover the whole of the overhead expenditure incurred on an output which is, say, 50 per cent. below capacity, this will undoubtedly inflate production costs. It will, therefore, be difficult to obtain true comparisons and, what is most important, view cost figures in their true perspective. In addition, it will be impossible to determine the effect of idle capacity. The following is an example :

Schedule "A."

Operating Capacity—		
(percentage of normal) ...	50%	100%
Overhead Expenses—		
Fixed	£3,000	£3,000
Variable	£7,000	£9,500
Total expenses	£10,000	£12,500

DIRECT OR PRODUCTIVE LABOUR—		
Wages	£7,500	£15,000
Man-hours...	100,000	200,000
OVERHEAD EXPENSE : RECOVERY RATES—		
Percentage on direct wages ...	133%	83%
Rate per man-hour	2/-	1/3
Percentage of reduction... ...	—	38%

It will be appreciated, therefore, that the problem which emerges is concerned not only with the distribution or apportionment, but, in addition, the control of overhead expenses. The only logical solution to be found is to base the rates for recovering overhead on the normal productive capacity of the plant and equipment available. The application of such normal rates, in a business working below capacity, will immediately bring to light the extent to which losses are being incurred due to unused capacity. While losses resulting from idle capacity are unavoidable, it is nevertheless essential to see that such losses are at least within the limits dictated by the conditions prevailing.

Take as an illustration, the depreciation of a machine amounting to £100 per annum, and assume the normal production to be, say, 2,000 hours in the year, the normal rate for depreciation will amount to 1s. per hour. If, however, the machine only works for 1,000 hours in the year, the depreciation would require to be increased to 2s. per hour, if it is desired to recover the whole of the expense over the reduced output obtained. The factory, however, cannot be held responsible for this increase in cost. The normal rate of 1s. per hour should, therefore, be charged in this case, which would have the result of showing an unrecovered expense of £50, which is definitely a loss resulting from idle capacity, but which must nevertheless be identified as such, otherwise it will be impossible to apply adequate cost control. We must therefore keep before us the fact that overhead expenditure is closely linked up with plant output capacity.

Maximum Capacity.

Maximum productive capacity is based on a conception of each unit of plant manufacturing independently without restriction or hindrance. A theoretical potential output is therefore established for each production centre, machine, or process. A complete summary of the plant as a whole will provide a measure of productive capacity, irrespective of practical restrictions, which may be imposed by an unbalanced output between departments, and many other causes. This standard of 100 per cent. could, however, not be attained in practice. It is nevertheless essential, in the first place,

to establish a theoretical maximum in order that it may serve as a basis for determining the normal capacity.

Normal Capacity.

This obviously represents a pre-determined standard of operating capacity which is less than the theoretical maximum, but can be realised in practice. Consideration is given to the desirability of obtaining a balanced output between departments or processes which operate inter-dependently Further, allowance is made for necessary periodical plant shut-downs to permit of repair work being executed. Finally, of equal, if not greater importance, is the necessity for fixing the normal on the capacity to manufacture and sell, not the capacity to manufacture only. In short, the normal should be something approaching 80 to 90 per cent. of the theoretical maximum, which can safely be taken as a basis with which to measure the degree of idle capacity in existence.

Degree of Idle Capacity.

Having determined normal capacity, it is desirable to ascertain over a period of years an indication of the extent to which variations occur in the degree of unused capacity, in order that the present trend of production in relation to normal may be apparent.

I do not wish in any way to minimise the difficulty which may be experienced in determining the normal capacity. Many businesses to-day will find that very little guidance in this respect can be obtained from past experience, with the result that one has to look ahead in the light of changed conditions. The important thing, however, is at least to fix a datum line, below which the recovery of overhead expense becomes uneconomic. Having determined what basis of output is to be taken as normal, the cost accountant thereafter should prepare a budget of all overhead expenditure pertaining to this output. The total expenditure budgeted for must be grouped under the two main headings—fixed and fluctuating.

It is important to note that the expenses represented by this budget should be the normal for the year. For example, take repairs and maintenance. It is found in many businesses that this has a tendency to rise and fall in different periods due to large repairs occurring only at infrequent intervals. If a sum of £500 is required, say, every five years for re-lining the furnace, then obviously the annual cost is £100. We cannot, however, expect to recover the whole of the £500 to cost of production during the period in which it was incurred. While it is appreciated that the whole of this expense of £500 must represent a charge in the financial accounts during the period incurred, before net profits are declared, we are nevertheless concerned with determining a true cost of production. Conversely, during a subnormal period, when expenditure on

repairs is low, it would obviously be unwise to take advantage of this when fixing overhead rates.

The choice of a suitable method by which overhead expenses can be charged or apportioned to cost of production will, to some extent, be influenced by works conditions, and, at the same time, by the extent to which accuracy is desired.

Percentage on Direct Wages Method.

Being simple in application, this is undoubtedly the most universally applied method, but in most cases, however, it is not conducive to an equitable distribution. The expenses are simply expressed as a percentage on the wages paid, and although separate departmental rates are established in this manner, it will be difficult to measure the efficiency of the recovery obtained in relation to the time taken, which is the important factor. Apart from this, where machinery is extensively employed, with wide variations in the amount of labour used, the expenses are only averaged throughout. Furthermore, hand and machine work will obviously involve different rates, but this distinction will be difficult to obtain with the direct wages method.

Rate per Labour-Hour.

This method is equally simple to apply, and to some extent overcomes some of the more serious objections to the direct wages method. A departmental allocation of the total expense budget is first accomplished, and thereafter the expenses are expressed as a rate per labour-hour, or man-hour, worked in each department. The main objection, however, to this method is the fact that it is impossible to distinguish clearly between hand and machine work.

Machine-Hour Rate.

The present day extensive use of machinery in production makes it desirable to adopt the machine-hour rate method of recovering overheads. The term " machine," however, also applies to individual processes, or productive units, or a productive department where machinery is not employed. It will be appreciated that, in view of the wide difference in capital cost and running expense of various machines, an individual rate is the most logical to apply. Further, on process work, charges for such services as steam, gas, water, etc., can only be satisfactorily distributed to individual machines or consumers. In addition, many firms employ specialised machinery, which is costly to maintain and operate, but cannot be wholly utilised, although essential to economic production. In such circumstances, therefore, it is desirable to see what contribution such plant is making to overhead recovery. The use of machine rates has a further advantage, as, once they are determined, cost information

can be very quickly ascertained, and the effectiveness of plant employed in production more closely kept under control. The same principle as regards determining normal rates will apply in this case as that referred to for the direct wages and labour-hour methods. It is, however, necessary to break down or analyse the operations involved departmentally in the production of the normal output, in order that an estimate of machine operating time may be taken out. If time study is applied to the various operations, the normal machine rates can be looked upon not only as a means of recovering overhead expenses, but, in addition, as a definite check on the efficiency obtained in production. The following schedule outlines briefly the principal elements of the machine rate, and the various suitable methods of apportionment.

Computation of Machine-Hour Rates.

(1) *Depreciation.*—On the basis of inventory, or book, value, or, if this is unsuitable, on "replacement value." This latter basis should always be used, when the book value is either in excess of, or less than, the current replacement value of the plant.

(2) *Repairs.*—The actual cost of repairs should be available for each machine, or at least for different groups of machines or departments. In the latter case apportionment should be made on the basis of the total machine hours for the department, or machine groups.

(3) *Stores.*—This includes cutting and lubricating oil, waste, and other sundry consumable supplies. The same remarks as regards apportionment apply as that given for repairs.

(4) *Power.*—ELECTRIC (DIRECT DRIVE)—Metered consumption of each motor. ELECTRIC (INDIRECT DRIVE)—Metered consumption of each motor, thereafter estimated apportionment to individual machines in ratio to "Load." (N.B.—In the absence of meters, the estimated consumption may be obtained in ratio to the H.P. for individual machines, or groups of machines, to the total H.P. of the department or factory.) STEAM—The cost per 10,000 lbs. is first obtained from the boiler service account, and thereafter apportionment is obtained: (a) By actual metered consumption, or (b) estimated in relation to the H.P. of the engine.

(5) *Floor Space or Rent Factor.*—This will include repairs, depreciation, insurance, lighting, heating, etc., of all buildings, which is apportioned on the basis of floor area, first to departments, thereafter to individual machines.

(6) *General Overheads.*—Under this heading is included: General repairs and maintenance, not otherwise included; depreciation of auxiliary plant and equipment; indirect labour; supervision; administrative expense (proportion), etc. These expenses should first be allocated to individual departments, where possible, and

thereafter to one general group, or account, for the factory as a whole. Apportionment is made on the basis of machine-hours.

Up to this point it will be clear that I am an advocate of the machine-hour rate method of recovering overhead expenses, and, further, that this rate should be based on the normal productive capacity of the plant. It remains to be seen, therefore, to what extent this contention is justified, as undoubtedly there is a considerable amount of work involved in making up such machine rates.

The application of incentive wage methods of payment for labour are quite common in industry to-day. Time study is scientifically applied with the object of determining the most economic method of utilising labour in production. Labour and overhead costs are, however, closely linked up; in fact, if the time allowed for an operation is exceeded, a fact which is often overlooked is that this will result in both an increase in labour and overhead cost per unit of output. Further, on certain operations, where spoilage is likely to occur, there will be an increase in material, labour, and overhead cost, all resulting from the same cause. The following example will serve to illustrate this point:

Schedule "B"—Analysis of Overhead Cost Variations

		s.	d.
Standard, or normal, overhead rate, per machine-hour ...		4	0
Standard, or normal, overhead cost per piece		2	0
Total production, gross ... ... pieces	2,000		
Less spoiled work ... ... ,,	200		
Total—nett production ... ... pieces	1,800		

Time taken ... 1,200 hours
Time allowed . 900 ,, (half-hour* per piece, good product).

	Actual	*Standard*	*Ratio to standard of* 100
Actual overhead cost, 1,200 hours at 4s.	£240		
Standard overhead cost of gross production, 2,000 pieces at 2s. per piece		£200	
Overhead cost ratio, gross ...			120

*36 minutes per piece on gross production.
40 ,, ,, nett ,,

	Actual	*Standard*	*Ratio to standard of* 100
Machine-effectiveness ratio (100 + 120)			83
Deduct spoiled work, 200 pieces at 2s. per piece		20	
Standard overhead cost of nett production, 1,800 pieces		£180	
Overhead cost ratio, nett			133
Spoilage ratio (133 + 120) ...			111

SUMMARY OF ANALYSIS.

Variation	*Ratio to standard of* 100	*Amount (inc'se)*
Machine-effectiveness	120	£40
Spoilage	11	£20
Total	133	£60

With the object of being specific, we shall assume that the foregoing analysis applies to a number of like machines in a department, all engaged on the same work. The normal machine rate is applied, which is in reality the standard, and explains the reason for using this term. It should be noted that the rate of 4s. per hour represents the cost of operating the machine exclusive of labour. It would be impossible to include the operator's wage rate, as this will obviously vary according to the standard of efficiency obtained, under the incentive method of payment which it is assumed is applied in this case. The standard overhead cost per piece is calculated at half-hour, or 2s. per piece. This time allowance is derived as follows: If we assume that forty minutes is allowed for doing the operation, and that the average worker will save ten minutes, or 25 per cent. of the time allowed, the standard cost should obviously be based on thirty minutes per piece. In the example given, it will be seen that the time taken on gross production was equivalent to thirty-six minutes per piece, but forty minutes per piece of good nett product. If we assume that the spoilage in this case is not attributable to bad workmanship on the part of the operator, but is due to either faulty material or workmanship at a prior operation or process, it is therefore necessary to measure the degree of efficiency obtained for the department under review, apart from such spoilage. Whilst cost figures are introduced with the object of determining the effectiveness of the machine, or operator, on gross production, the ratio of 83 shown can be arrived at by simply comparing the time. It will be recalled that a standard of thirty minutes per piece is

taken as the basis of measurement. The time taken, however, on gross production, was thirty-six minutes per piece; the efficiency obtained, therefore, represents only 83 per cent. of a possible 100 per cent., resulting in an increase in cost of £40, apart from the £20 increase in cost due solely to spoilage. Whilst the analysis given may seem rather "weighty," I would suggest that, from the point of view of production control, it is more essential to view cost figures, not in total, but at certain intermediate stages where such examination is likely to be profitable. In the illustration given, in view of the normal machine-rate being applied, production cost is not being inflated due to any variation in operating capacity compared with normal, but only when the time taken is in excess of that specified. In a business working below normal capacity, it is, as already mentioned at the commencement of this paper, essential to see that the losses thereby sustained are not excessive in the circumstances prevailing. The following example will serve to illustrate this point.

Schedule "C"—Analysis of Overhead Expenditure.

	Recovered in costs at normal rates	*Actually spent*	*Budget at normal*
Fixed expenses	£1,073	£1,555	£1,650
Fluctuating expenses ...	2,502	3,320	3,850
Total expenses ...	£3,575	£4,875	£5,500
Less recovered in costs ...		3,575	
Unrecovered (loss on idle capacity)		£1,300	

Degree of capacity used, 65 per cent. (ratio of recovered expenses to budget).

	Total	*P. cent. of Budget*	*Fluctuating*	*P. cent. of Budget*	*Fixed*	*P. cent. of Budget*
OPERATING VARI':	£		£		£	
Budget at normal.	5,500		3,850		1,650	
Recovered in costs	3,575		2,502		1,073	
Loss ...	1,925	35	1,348	35	577	35

SPENDING VARI':	*Total* £	*P. cent. of Budget*	*Fluctuating* £	*P. cent, of Budget*	*Fixed* £	*P. cent. of Budget*
Budget at normal .	5,500		3,850		1,650	
Actually spent ...	4,875		3,320		1,555	
Gain	625	11	530	14	95	6
Nett loss	1,300	24	818	21	482	29

The analysis given in the foregoing illustration could apply either to an individual department or the business as a whole. It will be seen that the plant was operated at 65 per cent. of the normal capacity, resulting in 35 per cent. idle capacity. The effect of such unused plant facilities is shown as a loss of £1,300, representing unrecovered overhead expenses. This net loss is, however, influenced in two ways, viz., operating and spending. The *loss* on operating is £1,925, from which is deducted the *gain* on spending amounting to £625, resulting in the net loss of £1,300 already mentioned. This amount requires analysing between fixed and fluctuating expenses, as the former cannot be controlled in ratio to output. Some economy should be apparent in fluctuating expenses when the plant is operated below normal capacity, and in the illustration given this economy represents 14 per cent. of the budget. It remains to be seen, therefore, if this reduction of 14 per cent. in fluctuating expenses is adequate, in view of the 35 per cent. degree of idle capacity.

The control of overhead expenses in the manner outlined will direct attention to the weak spots in an organisation and, at the same time, facilitate the examination of cost figures with a view to determining the real cause, or causes, of variations.

Discussion.

MR. WM. PATE: I would like to say how much I have enjoyed the paper to-night. We have had an excellent exposition of general principles and an indication of outlook, which is the important thing. The topic of budgets has figured very much in recent years and budgets are certainly very important from the negative side as well as from the positive. That may need some explanation. I mean that costing can look not only at the cost of what is made but also at the cost of not making up to the quantity budgetted. The point is referred to in Schedule "C." Admittedly the primary purpose of costing is to show what the works are doing but I think it might go further because all budgets are based on forecasts and unless the forecast is realised the works are saddled with enhanced costs for which lack of production is really responsible. On the matter of unit costing, I would like to hear the author's opinion regarding handling apprentices. A very troublesome problem in competitive work is the determination of cost when using apprentices, particularly where a percentage on wages is used to cover establishment charges. There is also the difference of opinion on the best basis for depreciation when considering estimates for the installation of new machinery—whether it should be on a fixed percentage applied to the diminishing value, a fixed annual amount, or by use of a diminishing rate starting at a comparatively high level. One buys a machine costing say £1,000 and in a year its competitive value is only half that amount. That is real risk resulting in a heavy charge which has to be faced for the sake of the future. There is another problem associated with machines bought at a low figure which are taken into the factory at nominal cost and meant to get the benefit of low depreciation. I would like to hear the author's idea of the correct way to deal with such circumstances. In connection with the determination of the fair load to expect from a machine, I gathered that each machine should be taken as a unit and judged accordingly, but I presume that individual machines must be considered in relation to others when determining the number of hours to be considered as normal. The layout of operations might call for only a small percentage of the available factory hours from a particular machine, and perhaps the author would make that point clear.

MR. WIGHT: I am very glad that Mr. Pate has emphasised the importance of budgetting from the negative side as well as the positive. It is one thing to determine what is the actual cost, but quite another aspect of the problem is presented when we seek to determine to what extent this actual cost falls short of what it

should have been. I would explain that the three Schedules "A," "B," and "C" already referred to, are intended to apply only to the factory or manufacturing side of the business.

In Schedule "C" a loss of £1,300 is shown, which has resulted from idle capacity, that is to say, production has been below the expected normal level on which the budget of overhead has been framed. The question of high selling costs referred to would naturally require to be dealt with entirely separately from the factory or production costs. I have not touched upon selling costs as I appreciate, being production engineers, you are largely concerned with the manufacturing side. It will be noted from Schedule "C" that the actual production represented only 65 per cent. of the normal, and that this fall in output has made it possible to reduce the actual fluctuating overheads by 14 per cent. Expressed in another way, this simply means that, taking the normal budget of production and overheads as 100 per cent., we find that whilst actual production represents only 65 per cent., the actual expenditure incurred on fluctuating overheads was 86 per cent. It remains to be seen, therefore, if the ratio between these two index figures is satisfactory; if so, the factory cannot be held responsible for the loss of £1,300 as shown. In a factory working below normal some attempt should be made to economise in expenditure on certain fluctuating overheads. The analysis given in Schedule "C," therefore, seeks to accomplish this objective.

The question of recovering overhead expenses, where apprentices are employed, is rather an involved one. If overheads are simply expressed as a percentage on direct wages, it will be found that, where apprentices are employed they are charged with a much lower proportion of overhead than skilled tradesmen, which is certainly not justifiable. Factory overheads should be directly related to the time taken to produce, and if the machine-hour rate is impracticable, the labour-hour rate should be used. Undoubtedly, a rate per machine-hour is the most satisfactory, as, by its use, it is possible to determine, by reason of the time factor, at which point it is desirable to employ apprentices, as against skilled workmen.

Regarding the question of whether depreciation should be calculated on the "diminishing value" or "original cost" basis; where overheads are recovered on a machine-hour basis, I have found from experience that the most satisfactory results are obtained if depreciation is calculated as a fixed percentage on the original cost, otherwise it will be found that the rate for depreciation is reduced each year. Unless this is compensated by increased maintenance costs, the machine-rate certainly does not remain stable year by year. The objective should be to provide for depreciation at a sufficiently high rate in order to eliminate obsolesence accruing in later years. The point which was raised about calculating depre-

ciation for second-hand machines, purchased at a low figure, is best answered as follows: If, when such machines are likely to become obsolete, they can be replaced again at a similarly low cost, it would seem that depreciation could readily be calculated on the basis of the actual cost price. Considerable risk, however, is attached to such procedure, and many firms, in such circumstances, prefer to calculate depreciation for costing purposes on the basis of estimated replacement value, when this is higher than actual cost or book value.

Normal Output: In fixing normal output it is not so much a question of determining maximum plant capacity, but determining maximum selling capacity and applying it to the existing plant. Obviously a balanced output between departments and machines must be maintained, otherwise the resultant overhead rates will not be realised in practice. The question of a machine which can only utilise two hours out of a possible eight; in this case two hours would be taken as the normal capacity of the machine.

Mr. J. McFarlane: Regarding the schedules, we, as a body of engineers, should be flattered that we are not being held responsible for any losses. I am not sure in connection with Schedule "C" in the fluctuating column whether Mr. Wight did not point out therein lay a possibility of the factory management having to accept blame in not having reduced the oncosts a little more, although one has to take account of both partly and wholly fluctuating oncosts. As far as the partly fluctuating portion is concerned, the executive had very little control. Referring to the item on spoiled work in Schedule "B," I think it is not fair to other departments that the department concerned should be excluded. In some concerns spoiled work becomes the particular "pigeon" of the department last operating upon it and the spoilage is debited against them. I would like to mention an article I read not so long ago which dovetails very well in with the lecture. In a certain printing establishment in the United States they chart their budgets for the oncoming period and find out the least percentage of economic output to square the costs based upon prices which are controlled by the sales organisation. On the chart appear direct costs also fixed oncosts and those partly and wholly fluctuating giving a total cost line and this line is intercepted by the price line (passing through the origin) at a point which locates the percentage of normal capacity below which there is bound to be a loss. The object as stated in the article was to control such items as fluctuating oncosts and, where necessary, it was up to the executive management to reduce such items of their fluctuating overheads if they could. The particular article appeared during the slump period of industry in the States and was intended to inspire firms to look carefully into their methods of cost control. With regard to the term "machine

hourly rate " I do not know if I understand Mr. Wight clearly, but if he called it a " unit hourly rate " it might be better, especially in small shops where we cannot divide them up into departments. We might have a planer and a fitter in the same department and the service of a labourer and possibly an overhead crane would not apply to the man at the bench. All these different groups would have their own particular rate applied to them. Another point: In obtaining this unit hourly rate are the administrative overheads also included because, if so, there is a part of these entirely out with the control of the works management and it is not fair to the latter if they are to account for something beyond their own control. I do not know whether I have misunderstood the author on that or not.

Mr. Wight: Regarding Schedule " B," Spoiled Work. While I appreciate that this department would be debited with the loss of £20, the important thing is to determine whether or not the department being debited is wholly responsible for such spoilage losses. Mr. McFarlane is correct in stating that I pointed out that the factory management should be held responsible for the control of fluctuating overhead expenses. In this respect I do not think we disagree. We do hear a lot about efficient methods in the U.S.A., but I rather think that, in some respects, they put a new name to something we have known for many years in this country. Take Standard Costs which are claimed as being of recent introduction. I can remember, as a youth in the cost department of a tube works, that it was quite a practice to take out standard costs. Thereafter we took out batch costs, from time to time, of actual production and compared the actual cost with the standard. It was an attempt to achieve a certain objective by setting an economic datum line to work to. I really believe that standard costs offer many advantages, particularly in businesses where measurement of efficiency is conducted by comparing costs in a retrospective manner, that is, from month to month. Machine Hour Rate: I mentioned that this would apply to a department not employing machinery, such as a fitting shop. You can have a unit rate in such circumstances which would serve the same purpose. The term " machine " is a general one. The cost of the overhead crane would be distributed over the machine hours in the department concerned. Adminstrative Overheads: I agree that these are no concern of the factory, but we come to a point where, in all fairness, proportion must be definitely charged to the factory, that is where there is one general office handling all sales administration and works problems. An apportionment will achieve a much better result than adding the whole cost of administration afterwards. To a large extent, administrative charges do not vary with output.

Mr. W. Buchanan: Can the speaker give us any average figures

for the fluctuating overheads? If we say this figure is 100 per cent. when working on normal output, what would be the correct figure for 50 per cent. of normal output, and also for 70 per cent. or 80 per cent. We realise it should be greater, but by what percentage? Do you mean by this system to have actually two cost budgets. The usual one and one to show the actual production costs. The losses as shown on this budget must be paid for. How is this taken care of? How do you allocate overtime? Some firms allocate it to the particular job on which it is worked and others use an increased rate for each class of worker to cover the amount of overtime worked.

MR. WIGHT: The point regarding the percentage of overhead expenses—which would be considered adequate or otherwise—is one which I am afraid I cannot answer unless I have some specific facts to work on. You suggest that if 100 per cent. productivity involved an expenditure of 100 per cent. on fluctuating overheads, a reduction of 50 per cent. in output should at least yield a 20 per cent. saving in such overheads. The relationship between these two index figures will naturally vary with different businesses, and individual circumstances must therefore be taken into account when fixing the datum line. The question of two budgets: I am not suggesting that there should be two. The fact that you do not recover all expenses is, of course, due to working below capacity. I am only suggesting that you budget for your overhead expense rates on normal output and then attempt to find out to what extent your actual expenditure is in line with the budget. The question of overtime allowances: The best method is to charge this direct to the job, if possible, otherwise, as Mr. Buchanan suggests, by increasing the rate of each worker to cover the overtime worked.

MR. W. P. KIRKWOOD: Mr. Wight has done engineers a great service in emphasising the great importance of idle capacity on the efficiency of works on the production side. We have long realised this but too often the costs department has glossed over the point. When we look for the normal capacity on any works for a period I feel this to be the predicted sales for that period. It does not matter whether the works can produce 2,000 or 1,000 if the sales department can only sell 200. The sales department should be compelled by the management to give an intelligent forecast so that the arrangements for manufacture can be handled efficiently. I am glad to notice he emphasises the relative values of labour costs and overheads so clearly. It is a point that is continually forgotten. Very often when it is found that a skilled operator is able to do his job in less time than was expected of him, the view is taken he is earning too much. But it should always be borne in mind whilst he may be earning a high wage, the time he is saving is a saving to the firm as well, at the ratio of one to the operator and two to the firm, and if the overhead wages ratio is the higher, the firm gains

in proportion. No matter how speedily he does the work the firm cannot be the loser. In regard to the question of depreciation, when he says that the replacement value should be taken, I take it that Mr. Wight means with some account of expenditure on repairs as we know that certain classes of machines cost considerably more to maintain than others.

MR. WIGHT: I agree that the sales department should provide a budget of their expected sales, but if this is going to be less than normal we must take a higher output for distributing the factory overheads. If the sales department expect, say, 60 per cent. of normal production will be sold, something higher than this should be taken for distributing factory overheads in order to keep production costs at an economic level, and therefore separate the factor of idle capacity. The budget of sales would therefore provide a measure of comparison with the productive capacity of the plant available. The objective is to find out to what extent production costs can be reduced by increasing production. As regards determining the replacement value of machines which involve a considerable expenditure on repairs, you must distinguish between normal maintenance and that which is increasing the value and life of the machine.

MR. R. J. LEYDEN: In the reconciliation of sales budget and factory capacity, should these be reconciled on the basis of single or double shift or overtime basis? This would appear to be rather an important point in the question of figuring overhead expenses.

MR. WIGHT: I think we would have to be specific, and I suggested at the commencement that we must not aim too high, but attempt to fix an economic level for overhead recovery. It might not involve working more than one shift, but if you are dealing with businesses where there is a great demand for mass production, where an eight-hour shift would not be economical, then some increase in time would require to be taken.

If you budget your costs on normal capacity you also have to budget the probable sales prices for the articles, and see if you can obtained the desired margin of profit. The problem is not easily solved as the basis of normal output will vary almost with every industry. Happily, we have different trade organisations who are getting together and considering what is to be taken as normal production for each industry as a whole.

MR. S. M. HARDAKER (Chairman): It has always seemed to me that the usual allowance for the depreciation of a motor car, is quite inadequate. We are allowed 20 per cent. for depreciation by the Revenue Authorities, and one would expect that after five years had elapsed, the car would be written off. My experience is that by such a method a car would never be written off. I have in mind a certain car which cost, when new, £600, and was standing in the books at approximately £40, was sold for £1. I was pleased to hear

the lecturer touch upon the question of replacement, and the distinction to be drawn between normal repairs, and improvements. I am definitely of the opinion, after many years' experience of the handling of these matters, that when the border line is reached, someone with the necessary technical experience should be able to guide the accountants' department, and instruct them as to when a particular item should be charged to either capital account, or to maintenance. I have found it a great advantage each year to have recorded in my plant book, for each works, the actual replacement value obtained in each case from the suppliers of that particular machine, for fire insurance purposes, as well as for a record of maintenance.

MR. WIGHT: Depreciation of a motor car: The same thing applies to an establishment buying a machine costing £1,000, with an estimated productive life of ten years, and expecting at the end of ten years that it will be entirely written off. It is found, however, that at the end of the seventh year it is obsolete, and £300 of obsolescence must be provided for. Whilst this £300 must be charged in the financial accounts, it cannot be justifiably charged to the costs for that year. The only solution offered, therefore, is to depreciate as adequately as possible and prevent obsolescence accruing, if at all possible. There seems to be a great difficulty in finding out depreciation rates on plant. Income tax schedules are certainly not a safe guide.

Taking plant costing £1,000 with an estimated life of fifteen years with a residual value of say £200, under the original cost method a depreciation rate of 5.3 per cent. is adequate, whereas with the diminishing value method the rate requires to be increased to 10.18 per cent. Insurance value is undoubtedly a sound basis as it represents the current replacement value. Revenue and capital expenditure require very careful classification. Repairs are often taken without consideration as to whether improvements are being carried out or not, and it is very desirable to make such a distinction in order to prevent loading the factory with too high overhead costs.

THE DEVELOPMENT OF MASS PRODUCTION IN THE GLASS BOTTLE INDUSTRY.

Paper presented to the Institution, Yorkshire Section, by

J. F. Shaw, M.I.P.E.

THE oldest record of the manufacture of glass, that can be relied upon with any certainty, comes from Egypt. Beads adorning some of the mummies discovered there are coated with a coloured glaze, which is a true glass, whilst among the tombs of Thebes pieces of blue glass, similar in composition to the glaze upon the beads, have been found. According to Flinders Petri, glass-making in ancient Egypt, as distinct from the glaze of pottery, dates back not further than 16600 B.C. and the method then employed was to shape the glass around a core of sand. It was not until many centuries later that ware was made from blown glass. The glass houses of Alexandria were long famed for their ware and Egyptian glass was carried abroad by the trading Phœnicians, who probably learned the art of its manufacture from this source.

Rome at one time imported large quantities of glass from Egypt, particularly in the first century B.C. As of course was natural with a country importing a large quantity of a manufactured article, the Romans began to turn their attention to its manufacture themselves, and many Egyptian workmen made their way there and a number of factories were founded. At the time of Nero, A.D. 54-68, the manufacture of drinking vessels was carried out. It was not until about 100 years later, however, that the industry began to flourish, and then the manufacture of glass assumed such proportions that a principal quarter of the city was given over to the glassmakers, and in A.D. 220 Alexander Severus levied a tax on them.

In the thirteenth century the Venetians were famed for their glassware, the industry nearly reached its greatest heights in the sixteenth and seventeenth centuries. It was so important that members of the Corporation of Glassmakers held a privileged position in the state and heavy penalties were imposed on any who went abroad and taught the art to foreigners.

France commenced the manufacture of glass in the fourteenth century, but it was a long time before her products rivalled those of Venice. In 1688 however Thevart of Paris invented the art of casting glass and was able to produce sheets of a size 84 in. × 50 in.,

Leeds, January 29th, 1935.

a much larger sheet than had up to this time been produced by blowing.

In England it was not until the year 674 that we had anything to do with the art of the glassmaker. In that year Bede stated that the Abbot Benedict sent for foreign workmen to glaze the windows of the church and monastery of Wearmouth in Durham ; these men were our first instructors in the art. It was not until the reign of Elizabeth, however, that any real development was made, and at this time the manufacture of glass was fostered by the state. At this time also a discovery was made which very soon revolutionised the whole industry, and undermined the pre-eminence of Venice. It was the discovery of lead flint glass, stated to have been first made in London in 1537 at Savoy House in the Strand. Covered pots for melting glass were also an English invention. In 1635 pit coal began to replace wood for the firing of furnaces. A great deal of credit must be given to the second Duke of Buckingham for improvement in English products. He brought Venetian artists to London for the manufacture of drinking ware and sheet glass. In 1696 Houghton gave a list of the glass houses in England and Wales, from which it appears there were about ninety—thirty-eight making bottles.

The chief ingredients in the manufacture of glass are alkali, lime, and silica. At the close of the eighteenth century two methods of obtaining alkali were in use. One method was to burn wood, the ashes lixiviated with water and by re-crystallisation a crude potash was obtained. The other method was to use the ash of seaweed, also purified by lixiviation and consisting chiefly of soda (sodium carbonate).

Of other material used 100 years ago, sand and limestone or chalk, are still used, the only change being the use of purer materials, particularly in the elimination of iron, the result being a glass of better colour. The use of ground flints as a source of silica has long been discontinued, and " Flint Glass " is no longer denoted because of the origin of its silica.

Up to the year 1872 glass was universally melted in pots, and to-day for some glasses this method is still in use, the factory with which I am connected still melt for some classes of bottle by this method. In the early furnace the pots were set in the furnace and directly heated by a centrally placed fire, burning wood as a fuel. By about 1850 coal had largely replaced wood.

The next furnace to make its appearance was the direct fired furnace. The furnace was built of refractory material in which were placed the pots. The fuel burns on the grate, the flames from which surround the pots, the products of combustion passing out of the furnace chamber through small flues into the chimney and so to the atmosphere. In a furnace of this type, constant attention must

be given to the fire as the greatest possible heat must be attained in the furnace, a temperature of 1300 degrees to 1350 degrees C. being required round the pots. It will be readily understood that in a furnace of this description the efficiency is very low, the flames passing into the flues at a temperature very little below that at which they entered the furnace, and so a great amount of heat is lost. Inattention to the fires on the part of the furnace man, with the resultant variation in temperature would result in disaster to the pots, causing cracking and breaking, and allowing the molten glass to run over the " siege " as the bottom of the furnace is called, and on to the fires. In a furnace of this type three to seven tons of coal are required to melt one ton of glass, this fact alone being sufficient to condemn any furnace at the present time, although I myself can well remember furnaces of this type being used in Leeds.

Mention has been made several times of the pot, in which the glass is melted. This is made of fireclay, entirely by hand, and by a very careful, slow, and lengthy process, which I do not propose to deal with to-night ; it will be sufficient to say that the old potmaker was a very respected member of any glass factory, as faulty pot-making could be a source of great loss. Before a pot can be put into a furnace it is necessary to heat it up as near the furnace temperature as possible ; this is done by means of the " pot arch." The pot is placed in the pot arch and very slowly heated for a number of days, the pot is then gradually brought up to temperature and then set in the furnace.

The next step in furnace design was the introduction of the semi-direct fired furnace. In this type of furnace, use is made of recording air for the burning of the gases coming from the fuel bed. The coal is burnt in the firebox, the products of incomplete combustion pass through the " eye " ; here they are met by the secondary air which passes through the channels round the firebox, the burnt gases pass through the flues and then to the chimney. This type of furnace was a distinct advance on the direct-fired furnace ; one ton of glass can be melted for the expenditure of two tons of coal. It will be noticed that the floor of the furnace slopes upwards towards the " eye " so that in the event of pot breakage the glass cannot get on to the fire. A defect of this furnace was, that unless there was a strong chimney draft there was a positive pressure in the furnace and so secondary air was prevented from entering, causing incomplete combustion. In cases where this happened the secondary air was blown into the furnace by means of a blower.

In the year 1860 a great revolution in furnace design followed the introduction by the brothers Siemens of the heating of a furnace by means of producer gas, and the regenerative pre-heating of gas and air. In this gas producer the gas passes into the

furnace through the port where it is met by the pre-heated air coming from the regenerators. An interesting point is the provision of a glass pocket.

It was in 1872 that the greatest advance in furnace design was made, and without which the fully automatic bottle machine would be an impossibility. That was the introduction by F. Siemens of the regenerative " tank furnace " (supposed accident of tank breaking of pots in side port pot furnace).

In the continuous tank furnace there is a melting and working zone. The raw materials are introduced into the furnace through a " dog house." This is a box-shaped projection at the end of the melting zone. The raw material is shovelled into the dog house and is pushed at intervals into the furnace, through a hole below the level of the raw materials. Charging by this method prevents the entry of cold air into the furnace, the raw materials are also hot when pushed in. They are also better distributed over the surface of the glass in the melting zone ; it will be seen, therefore, that an even temperature is more easily kept. The gas flames sweep across the furnace and melt the raw materials, the furnace temperature at this point being between 1,350 and 1,400 degrees C.

As the workmen or machines draw the glass out of the working zone, the glass in the melting zone is drawn towards it. Now, as both workmen and machines draw the glass from the surface, it will be readily seen that there is a tendency for the partly melted raw materials and also any impurities floating on the surface to be drawn to and into the working zone, resulting in " bad metal." To prevent this, a bridge is built across the end of the melting zone to above the glass level. A hole, known as the dog hole is left, through which the glass can pass from the melting to the working zone. The " dog hole " is usually about 12 in. square and is on or slightly above the furnace floor level. The working zone of the furnace is usually semi-circular in shape. As it is necessary that the temperature of the working zone should be less than that in the melting zone, glass at 1,400°C. being too hot to work, some system of checker work is usually built on the bridge to bring the temperature in the working zone down to about 1,250°C.

During recent years many furnaces of the recuperative type have come into use. Recuperative heating is continuous, requiring no reversal and one set of chambers only. Recuperative troubles—lack of conductivity of heat through tubes—tendency to crack and allow air and waste gas to mix. Oil fired furnaces much simpler to construct—easy to control—but very expensive.

With the development of the melting furnace there came also the development of the gas producer. Three forms of producer gas are in common use to-day.

(1) Air gas or simple producer gas, obtained by passing air through the mass of incondescent coal or coke.
(2) Water gas, produced by passing steam through the incondescent fuel.
(3) Mixed producer gas, obtained by the use of steam and air simultaneously. It is the mixed producer gas that is commonly known as "producer gas."

The Siemen's producer is an air gas producer, consisting of a rectangular chamber with an inclined front. Air steam gas is the gas most commonly used for furnace work. The Duff producer is a producer for this gas. It consists of a chamber which can be either square, rectangular or cylindrical. Running across the producer at the bottom is a V grate through which the air and steam are blown. The fuel is charged in intermittently and the ashes, which slip off the inclined grate, are removed periodically from the water trough, which seals the producer bottom. Poker holes are provided in the top, the settling of the fuel being assisted by poking. This type of producer is in common use to-day.

From the static "mixed gas" producer we get the mechanical grate producer and then the mechanical producer. The Morgan gas machine is a producer of the latter type. The makers of this producer deny that any agitation of the fuel bed is necessary, and say that "if the coal is properly spread and the furnace continually levelled, all that the fire needs is to be left alone." Other disturbance causes variations of density which create hot places and consequently poor gas and clinkers.

In this producer there is a continuous cool feed on the fuel bed and, as the whole machine revolves, the leveller bar keeps the surface of the bed level. The leveller bar floats, and it can therefore take care of any variation in height of the bed.

The blast is delivered from three hollow radial arms which connect with a hollow ring going round the whole circumference of the producer. A steady pressure is therefore distributed in the fuel bed. The producer is water sealed and a plough is provided for the removal of ash. The whole of the revolving parts are supported on three large rollers. A producer of this type is capable of gasifying 3,000 lbs. of coal per hour.

After a bottle is made it must be annealed. The reason for this is that glass cools at a very rapid rate and as the outside will cool quicker than the inside, strain is set up and fracture will result. To obviate this the bottle must be slowly and evenly cooled. This is done either by means of the "kiln" or the "lehr." The kiln consists of a brick chamber at the front of which is a door of sufficient size for the convenient introduction of the glassware. In the roof of the kiln a dampered chimney is provided. There is a coal or coke fire near the door. As the bottles are made they are placed

in the kiln one on top of the other until it is full. The kiln is then sealed and allowed to cool. It will be seen that this method of annealing is a slow and uneconomical process and for mass production is useless, as it takes three days to anneal a bottle. The method used to-day is by means of the continuous annealing furnace or "lehr." The lehr consists of a tunnel varying usually between 80 and 90 feet long, through the tunnel passes an endless belt. The front end of the lehr is heated, sometimes by a coke fire, but usually by gas. The products of combustion are allowed to pass down the tunnel to a chimney placed down the lehr, approximately three-quarters of its length. By this means a gradual falling temperature is obtained down the tunnel. The articles to be annealed are placed on the belt, which slowly moves through the tunnel and so are gradually cooled, the process taking about three to four hours.

Now a bottle immediately it comes from the machine as the finished article, contains more heat than is necessary for its own annealing. This led to the introduction, in recent years, of the so-called "heatless lehr." The function of this lehr is simply to utilize the heat in the bottle for its own annealing, thus effecting a great saving in fuel. It consists of a long tunnel, as in the case of an ordinary lehr. The belt is known as a rotress belt, similar in appearance to a spring mattress. The sides of the lehr are heavily insulated, asbestos being used. To maintain a proper temperature drop, the heat can be drawn off at various points down the lehr. A fuel oil burner is provided at the front, to heat up the lehr to annealing temperature should it have been stopped for any reason. It is also used when small bottles are being made as they lose their heat very quickly. The time taken to anneal in this lehr is about two hours.

We have now dealt with the development of the essential plant necessary for the manufacture of glass, without which the mass production methods in use to-day for the production of bottles would be impossible. We will now follow the actual manufacture of a bottle from its beginning.

The chief ingredients of glass are : silica, soda, and lime. I do not propose to deal at all with the chemistry of glass, that is a question for my friends at Sheffield University. A batch for the manufacture of glass, very suitable for white bottles is : sand, alkali, limespar, felspar, borax, arsenic, decolouriser.

The ingredients are carefully weighed and mixed in a mixer of the concrete type. The batch is then filled into the furnace and melted.

In the old "flint-hand" process the men work in sets of three men and a boy, called a "chair." There are two "blowers," a "maker," and a "taker-in." The blower gathers the molten glass on the end of a mild steel pipe, which is usually about 5 ft. long

and ¾ in. thick, with a ¼ in. hole. He does this by allowing the pipe nose to touch the surface of the glass, and then by twisting the tube gathers the glass on the end. He immediately takes it and shapes it on a "marver," making and blowing the "parison," after which he transfers it to the mould and by mouth blows it up into shape. He then takes the blow pipe with the adhering bottle and with the aid of a pair of dull shears cuts a groove in the neck of the bottle just below the blow pipe. A slight tap on the pipe and the bottle breaks away at the sheared mark. The bottle is then taken up by the maker in what is known as a punty, and the neck is re-heated in a small by-furnace or "glory-hole." When it reaches the desired temperature, the maker then finishes off the neck. He does this by rolling the punty containing the bottle up and down the chair arms and by means of tools or dies, shapes the ring. The bottle is then taken by the boy on the end of a long iron rod and placed in the lehr to anneal.

It occurred to Ashley, of Castleford, that a lot of the work done in making a bottle by hand could be done by mechanical means. He therefore, introduced the "parison" or blank mould, which is equivalent in its action to the marvering and blowing of the glass. He also introduced the use of compressed air for the blowing of the bottle. These ideas form the basis of all bottle machines of the present time, that is (1) the shaping of the parison or blank, and (2) the blowing up in the finishing mould. Improvements were rapidly made on the early Ashley machine, of which the Schiller is one, many machines of this type are in use to-day, being very suitable for some classes of ware (small light bottles).

From the stationary machine of the Schiller type, the semi-automatic or hand-operated machine, made its appearance. This was quickly followed by the fully automatic machine of which the Lynch and O'Niel are the most widely used to-day. Known as gravity or drop machines. Air pressure—35 to 40 lbs. per sq. in., safeguard against breakage. Two tables, 10 to 25 bottles per minute, Lynch, 10 to 45 per minute. With the introduction of the fully automatic machine it became necessary that automatic methods should be employed to feed it. The first feeders to be used were of the flow type. Next came feeders employing a plunger to assist in the function of the "gob" of which the Miller was one of the first.

Now in designing a feeder the first thing that must be remembered is, that a given amount of liquid will flow through a given orifice, in a given time at a given temperature. Now in a glass feeder the only thing that can vary is the temperature. In a Miller feeder if this occurs the weight of the glass delivered will vary. This can be regulated to some extent, by varying the height of the plunger, with respect to the orifice, but at the expense of the shape of the

"gob." Keeping this fact in mind Rankin patented his feeder, and a very successful machine it has proved to be.

This particular feeder in turn had its faults and has been superseded by one of improved design, which we are working to-day.

The bottle machines so far considered have been "feeder fed machines." There is another method of making bottles, by automatic method, and that is by a process patented by Owen early in the present century, known as the Vacuum or Owen process. The machine used for this process is a continuous rotary machine and is electrically driven—six H.P. It consists of a number of "arms," "heads," or "units" as they are called, located radially around a central column, the column being mounted on a travelling bed. Each "head" is a complete bottle-making unit, and carries its own blow mould, parison mould, neck rings, and plunger. The mechanical movements of each head being actuated by stationary cam paths fixed to the central column of the machine. The machine operates in conjunction with a "revolving pot." This is composed of a combustion chamber over a revolving shaped pot. A portion of of the pot, about 16 in. to 18 in. is left exposed beyond the walls of the combustion chamber. The parison moulds of the machine dip into the exposed section of the glass, consecutively, as the machine revolves. As they touch the glass a vacuum is created in the mould and the glass is sucked up into it, forming the parison.

As the parison mould rises away from the glass a knife cuts off the tale of the glass. As the machine rotates the parison mould opens leaving the glass parison suspended in the ring mould. The blow mould then rises and closes round it. Compressed air is then admitted and the parison is blown up to the finished bottle. At a later stage the bottle is ejected from the machine.

In conclusion, it will perhaps be of interest to compare the production of the different methods of manufacture. Considering a bottle of eight oz. weight :

By hand, in seven hours, 1,400 bottles (three men and one boy).

By Schiller Machine, in seven hours, 2,000 bottles (three men and one boy).

By Schiller machine, in seven hours, Duplex 5,000 1-oz. Pomade.

By automatic machine Lynch A, in seven hours, 8,400 bottles (20 per minute) (one man and two boys).

By automatic machine Lynch 10, in seven hours, 12,600 bottles (30 per minute).

By Owen Suction,	6 arm	(seven hours)	8,400	bottles.
„ „	10 „	„	14,700	„
„ „	15 „	„	21,000	„

For certain kinds of bottles, a much bigger production than this can be obtained on a suction machine, this is done by the plural mould operation. This is where there are three bottles made at

one time in each head. There is an actual case of a bottle of a ¼-oz. capacity being made three in each mould, on a ten-arm machine. The machine revolved at six r.p.m. and over a period of seven days produced an average of 10,080 good bottles per hour or 1,680 gross per day.

Discussion.

Col. G. Bray (Section President, who presided) thanked Mr. Shaw for his excellent paper. Mr. Shaw must have had an enormous amount of preparation both of the paper and of the beautiful slides. It had been very fascinating with attractive trade terms such as "glory hole," "dog hole," and so forth. Mr. Shaw had very kindly offered to take a party over his works.

Mr. Shaw had brought with him specimen parisons, moulds, and sample bottles, and the Chairman invited the members to inspect these, and stated that Mr. Shaw would be pleased to answer questions.

A bottle made by the "gravity" process was shown, and when examined critically it could be seen that the walls of the bottle were very uneven. This specimen had been brought to show the waves. It was stated that with the vacuum process you do not get this waviness, and Mr. Shaw expressed the opinion that the vacuum process of bottle manufacturing was the best.

The cast iron moulds were next examined and Mr. Shaw was asked if chromium plated moulds would not be more serviceable. Suggestions were also put forward that perhaps the chrome varieties or high tungsten steels might be more serviceable. Mr. Shaw was asked if there were any erosion effects at all on the dies with the hot glass to which he replied there was not, and to a question as to whether there was any scouring action he replied there was a certain amount. Mr. F. T. Nurrish said he thought it might be advantageous to investigate the alloy steels where there had been tremendous developments during the past few years. On being asked the life of a mould Mr. Shaw stated that for an outlay of £80 to £100 they could make anything up to 20,000 gross with various replacements, i.e., repairs done in their own shops.

A question was asked why arsenic was used in glass manufacturing. Mr. Shaw stated it was used as a purifier and selenium was used as a decolouriser, the natural colour of glass being green. It is impossible to change the colour from green to white, but it is possible to neutralise it with selenium.

Mr. F. T. Nurrish remarked about the gas producer and stated there did not appear to be a lot of dirt in the glass due to a filthy

atmosphere. He asked Mr. Shaw if the gas was washed to which he replied that it was not. Mr. Nurrish said that cleanliness must be an important factor but Mr. Shaw said they had no trouble.

MR. R. J. MITCHELL asked Mr. Shaw if they were ever required to supply special heat resisting glass such as "Pyrex" to which he replied that that was a special line.

MR. NURRISH stated that Mr. Shaw had told them that the machines were not complicated, but to him they looked a real "Chinese puzzle."

MR. SHAW replied that when it was realised that each "head" was exactly like its neighbour they were not so complicated as they seemed.

A MEMBER stated he would like to know more about the belt on the "lehr."

MR. SHAW stated it was made of mattress wire about 200 ft. long. It was liable to stretch when new, and after a short time it was necessary to cut out about 20 ft. A suggestion was put forward that stainless material and heat resisting steels might be investigated.

MR. NURRISH raised the question of electrically annealing the bottles, mentioning the manufacture of electric light bulbs and the practice of the General Electric Company of America.

MR. SHAW explained that there was no weight in these, and that heavier materials would be much more expensive to anneal, and stated he did not think it would be a paying proposition.

MR. MITCHELL asked if carboys and Winchester quart bottles were made by hand.

MR. SHAW said they were. The trouble with mass production machinery was the lack of orders sufficiently large to warrant their use. Chemists wanted their own names on the bottles and would order say in five gross lots. Such orders were, of course, executed by hand made methods.

MR. NURRISH asked why babies' milk bottles could not be made on a machine or, say, three quarters by machinery.

MR. SHAW stated they had had no success with it, largely due to the double ended shape of the bottle which largely complicated the mould problem.

BAKELITE MATERIALS.

Paper presented to the Institution, London and Southern Sections, by G. J. Taylor.

SINCE this paper will be supplemented by the showing of our film "The Story of Bakelite," I propose to restrict my introductory remarks to a very brief explanation of what bakelite material really is. By bakelite material I mean bakelite resin which is the basis of all bakelite materials.

Two important materials are used in manufacture, namely, phenol or carbolic acid, and formaldehyde, a product of wood distillation. Subjected conjointly to specific conditions of heat they react and form a hard resinous substance known as bakelite resin "A." It is an amber coloured product soluble in alcohol, acetone, and other organic solvents. The melting point is in the neighbourhood of 120°F., but further application of heat changes the resin to a state in which it is still fusible but insoluble. This is known as the "B" stage. If the heat treatment is still continued the "C" stage is reached when the resin becomes both infusible and insoluble.

Bakelite Resin "C" or Bakelite Transparent is supplied in slabs, rods, and sections and can be readily machined. It is largely used for imitation jewellery, handles for domestic utensils, cigarette holders, umbrella handles, laboratory equipment such as funnels and beakers, and in certain cases for oil gauges where the use of glass is impracticable. Bakelite resin is used as the bonding agent for grinding wheels The resin, when finely ground, is mixed with a wetted abrasive grit until a paste is formed and the whole loaded into the mould. A pressure of one ton per square inch of the projected surface area is then applied and after the wheel is ejected from the mould it is heated slowly to a temperature of 175°C., which heating has the effect of driving off the solvent and bringing the bakelite resin to that state of infusibility referred to previously. It is usual to run a bakelite bonded wheel at 9,000 feet per minute whereas 5,500 feet per minute is the usual cutting speed for wheels made with other bonds.

Special bakelite resins are used for impregnating friction or brake linings. A fabric lining so treated will withstand extremely high service temperatures. The process of manufacture consists of, firstly, impregnation of the fabric; secondly, slight heat treatment to induce a partial reaction of the resin; thirdly, application of

London, April 5th; Southampton, April 17th, 1935.

heat (175 to 200°C.) and pressure in a closed mould to complete the reaction and, lastly, machining to correct shape and thickness.

Other bakelite resins are soluble in oils such as china wood oil and linseed oil. These are used in the preparation of oil varnishes and paints. The resultant product, after application to the surface to be treated, gives speedy air drying or stoving finishes. The varnish or paint film so obtained is extremely durable, flexible, and resistant to weak acids and alkalis. These varnishes have found particular favour for marine and industrial finishes.

Bakelite insulating varnishes are mostly solutions of the bakelite resin "A" in alcohol Their chief application is found in the impregnation of coils, providing a very high degree of insulation and rigidity. The varnish may be applied by vacuum and pressure impregnation, dipping or brushing dependent upon the type and ultimate function of the coil to be treated. After application the coil must be heated slowly to a temperature of 120 to 130°C. Coils in general, treated with bakelite varnish, will withstand high operating temperatures and are therefore most suitable for service in tropical climates. The windings of armatures remain inert and do not ride over each other or loosen due to the centrifugal force set up during rotation.

Bakelite cements are employed for adhesive and bonding purposes. They may be divided into two groups, liquid and solid. The liquid form is an amber coloured viscous substance and is used in abrasive wheel manufacture. The abrasive grit is mixed with the cement in a warm mechanical mixer and then discharged into the wheel mould. Pressure is applied, the wheel form is then ejected and stoved in an oven for a period of six to 12 hours at a temperature of 175°C. Abrasive discs are made by brushing the steel plates of disc grinders with cement, sprinkling an excess of grit on to the coated surface, lightly rolling and then stoving for four to six hours increasing the temperature of the oven from normal to 175°C. Discs so made are free, fast, and cool cutting; in fact, tests show that their life may be from 4 to 30 times that of cloth backed discs.

Bakelite cement in liquid form is also used for the setting of brush bristles. Briefly, the method of use is to insert the knot of bristles into the ferrule, pour cement into the ferrule and on the knot, allow the cement to penetrate a little way down the bristles, then pour off the excess. Rapid heating to 150°C. prevents penetration of the cement to the business end of the brush. One final word on liquid bakelite cement; it can be used as a jointing medium for various materials where a chemically resistant union is desired. In application, the surfaces to be united should be cleaned free of dirt, grease and moisture, a thin coating of the cement applied, heated to about 100°C. until the cement is tacky and finally the

surfaces united, clamped together and stoved to complete the hardening process.

Probably the widest application for bakelite cement in powder form is found in the manufacture of electric lamps and radio valves. The cement is worked into a paste by the addition of alcohol. The paste is then applied to the lamp or valve socket, the glass bulb placed in position and fed into the head of the lamp capping machine for stoving and ultimate soldering of the filament leads.

This paper would not be complete without some reference to bakelite lacquers which are, in the main, solutions containing bakelite resins together with certain other materials, in a variety of solvents. The application of bakelite lacquers to the bright surfaces of metal furniture preserves the finish, prevents tarnishing and provides a surface coating resistant to highly corrosive conditions The lacquers may be applied by brushing, dipping or spraying, the solvent is then allowed to evaporate at room temperature following up with a stoving process at or about a temperature of 122°C. Reference has been made to the use of this form of bakelite material for metal furniture ; it is also employed for the colouring of electric lamp bulbs and glass sheet, or letters for illuminated signs.

Laminated sheet, which is one of the two most important industrial forms of solid bakelite material, consists of superimposed layers of paper or fabric impregnated with bakelite varnish, the whole subjected to heat and pressure to form a homogeneous mass. In manufacture the paper or fabric is passed slowly through a tank of bakelite varnish, thence to a drying oven in which the solvent is driven off. The impregnated sheet is cut up to size, a number of the sheets are placed one on top of the other in the form of a pack and then inserted in a hydraulic press having steam-heated platens of suitable size. The temperature employed for hardening or curing is about 375°F. and the pressure about $\frac{3}{4}$ ton per sq. in. The paper base sheet is made in a variety of grades, some grades have high electrical properties, others are specially produced for punching whilst others by virtue of a superimposed layer bearing a photographic reproduction of wood grain or other distinctive pattern are used for decorative purposes.

The paper and fabric base sheet can be readily punched, drilled, tapped, sawn, turned and ground ; in fact all machining operations can be carried out adopting feeds and speeds approximating those used for brass. In punching, the sub-press or progressive types of tools are generally used, clearances between punches and strippers should be kept to a minimum and the best results are obtained with clean sharp tools. Specially designed drills and taps are now manufactured for use with bakelite laminated sheet. The drills embody a 60 to 90° point to prevent chipping or delamination when breaking through, a slow angle of twist for speedy ejection of " swarf " and

wide flutes with the cutting edge well backed off to prevent overheating. Bakelite materials are notoriously bad conductors of heat.

Taps should have wide flutes and the cutting edges backed off; the three-flute type is the most popular. Too much emphasis cannot be laid on the importance of keeping the taps sharp. For circular sawing, the saw should have about four teeth to the inch, no set on the teeth and hollow ground or relieved toward the centre. The peripheral speed should be about 2,500 to 3,000 feet per minute. Turning tools should preferably be diamond tipped, but an excellent substitute has been found in tips of a tungsten-carbide alloy. When grinding, a wheel of not less than 36 grit should be employed, otherwise glazing takes place.

The fabric base sheet finds a considerable outlet in the manufacture of gears and pinions. The wide application of this type of material may be judged from the fact that it is supplied for drives in household electric clocks to the 300 h.p. motor pinions of rolling mills. Bakelite gears do not require shrouds or end plates, give a considerable factor of silence and furthermore are resistant to water, oil, steam and atmospheres containing corrosive chemicals or abrasive particles.

Bakelite silent gear material is bandsawn or trepanned in blanks, the particular operation adopted depending on the number of identical blanks to be cut. The teeth of the gears may be milled, shaped or hobbed on all modern gear cutting machines but backing plates must be used to prevent chipping or fraying as the tool leaves the material.

Lubrication of bakelite silent gears is unnecessary, but, should this condition be desirable for the metallic meshing gear, a mixture of two lbs. of heavy grease to one oz. of flake graphite is recommended. Here are a few of the physical properties of bakelite laminated products :—

	PAPER	FABRIC
Specific gravity	1.3—1.4 (which is half that of aluminium and one-sixth brass or steel).	
Tensile strength (lbs. per sq. in.)	8,000—24,000	8,000—12,000
Modulus of elasticity (lbs. per sq. in.)	500,000—2,500,000	1,000,000—6,500,000
Modulus of rupture (transverse lbs. per sq. in.).	15,000—30,000	15,000—25,000
Breakdown voltage (volts per mil, or 1/1,000th of an in., instantaneous at 60 cycles).	500—1,300	200—500

Now we come to bakelite moulding materials which consist of bakelite resin in the " A " stage plus a reinforcing material or filler

and a colour pigment. They are supplied to the moulder in powdered or granular form and need no mixing or modification. In fact, such a procedure is to be strongly deprecated, for the addition of foreign substance will destroy the specific qualities for which a given moulding material is designed and produced.

There are three fundamental types of bakelite moulding material: (1) embodying a wood meal filler which produces a general purpose moulding material; (2) embodying a mineral filler giving heat or alternatively water resistant properties; and (3) embodying a fabric filler where a greater degree of shock resistance is required.

Here are some of the physical properties:

	WOOD FLOUR AND FABRIC FILLERS		MINERAL FILLER
Specific gravity ...	1.3 to 1.4		1.8 to 2.0
	WOOD FLOUR	FABRIC	MINERAL
Tensile strength (lbs. per sq. in.).	6,000 to 12,000	4,500 to 9,000	5,000 to 10,000
Impact strength (ft. lb. per sq. in.).	1 to 2.5	10 to 25	.5 to 4
Modulus of elasticity (transverse, lbs. per sq. in.).	2,500,000	800,000 to 2,500,000	1,000,000 to 2,500,000
Breakdown voltage (volts per mil) instantaneous at 60 cycles.	300 to 500	200 to 500	Asbestos 150 to 400 Mica 450 to 600

A multitude of colours, wood finishes and mottled effects are available in the wood meal filled materials, whilst a somewhat lesser range of coloured effects is obtainable in the heat, water, and shock resistant types.

In the process of manufacture the first operation consists of the thorough impregnation of the filler with the bakelite resin and pigment in heated mixers. The resultant mass is allowed to cool, then ground, sieved, and blended. At various stages in the process of manufacture the material is passed over magnetic separators thus preventing the possible presence of any ferrous particles. Frequent tests are made for degree of flow, rate of cure, consistency of colour, bulk factor and proportionate mesh of grinding; the latter plays an important part when the cold performing of the moulding material is carried out by the moulder since the size of mesh controls to a great extent the adhesion of pellets or preforms. The latter are used for the speedy and correct loading of multiple impression moulds.

The moulding process consists of the application of heat and pressure—heat at 300 to 375°F. and pressure at one to two tons per sq. in. of the projected surface area of the moulding to be produced. Greater pressures are used for articles of extreme depth. The time required for ultimate curing and hardening may vary from forty seconds in the case of a collapsible tube or bottle cap to ten minutes for a large radio cabinet.

The moulding plant consists of presses, usually hydraulic, but hand, screw, or mechanically driven types are occasionally installed. A large plant, hydraulically operated, will include pumps and accumulator, whilst a small plant may consist of self-contained presses, the pump unit forming part of the press. The presses are fitted with hot plates, heated by steam, electricity, or gas. In certain cases hot plates are dispensed with and the heating arrangement incorporated in the mould. During the last few years the bakelite moulding press has been improved in many respects, mainly with the objects of speedier operation and production in view. Multiple daylights are used where portable moulds are employed. Semi-automatic ejection is provided for moulds built into the press, whilst dual tools, traversing on rails through the press, are necessary where the mouldings must needs be unscrewed from the tool. Split moulds necessitated by the contour of the moulding, are assembled and separated by a horizontal ram.

The moulds are made from high grade steels and carefully hardened. The steel used should possess the following attributes: ready machinability, non-movement or shrinkage on hardening, and non-staining.

Where multiple impressions of a given article are to be incorporated in one bolster, it is usual to hob rather than machine the impressions. The process of hobbing consists of forcing a hardened steel master into a relatively soft steel blank. Both hob and hobbing are enclosed in a bolster of massive proportions since the pressure necessary to carry out this operation may be from 200 to 1,000 tons, dependent upon the size and shape of the impression to be hobbed.

Bakelite moulding materials repeat with almost photographic fidelity the finish of the mould and where extremely high lustre is required chromium plating of the mould surfaces is considered standard practice. Bakelite mouldings when ejected from the moulds are more or less finished products; it merely remains for the fin, flash, or spew to be removed. The most popular method is by tumbling. The mouldings are charged into a revolving drum together with some polishing medium in the form of scraps of leather, celluloid or similar material. Larger mouldings may need individual treatment; the fins are removed by linishing band, abrasive disc or file, dependent upon the contour of the piece. Where a joint in the mould produces a fin on an otherwise flat surface, removal

may be effected by mopping or buffing, using a Tripoli cutting compound on a stitched linen mop.

I feel sure that you will all be familiar with many of the everyday articles for which bakelite moulding material has been adopted. There is the new post office micro-telephone handset some radio manufacturers have utilised a moulded bakelite case for sets and loud speakers, whilst lampholders, switches and other lighting accessories are extremely popular.

No small part is played in the control of the transmission of broadcast programmes by instruments mounted and insulated in moulded bakelite. Door furniture of every conceivable shape and design is now available and one of our largest London hotels has adopted the moulded bakelite lavatory seat because of its lasting finish and hygienic properties. The chemists' and druggists' shop windows bear witness of the ever-increasing adoption of moulded bakelite closures and packages for cosmetic and toilet preparation. It has been suggested that the day is not far distant when we shall live in bakelite houses and drive motor cars fitted with moulded bakelite bodies. Obviously considerable development will be necessary before such ambitious projects are achieved. It is, however, but a short time since we should have looked aghast at the proposal to produce a bedstead foot and head or even a radio cabinet.

THE MAKING OF A PRODUCTION ENGINEER.

(Copy of pamphlet issued for the information of engineering students and apprentices.)

Introduction.

IT has been suggested to the Council of the Institution of Production Engineers that many young men engaged in engineering, especially towards the end of their apprenticeship, are in difficulties as to the best method to adopt so far as technical education is concerned. Often, too, they are in doubt as to whether they have any special aptitude which would fit them for one of the specialised sides of engineering, such as production engineering. As there may be many such who would, no doubt, in later years qualify as production engineers, the following information has been compiled at the request of the Council for the guidance and information of engineering students and apprentices.

Where are you Heading ?

Every apprentice, whether he be indentured or not, who is engaged in engineering and wishes to progress must sooner or later ask himself the question—where am I heading ? Only he himself can supply the answer, and before he finally decides he must review the probabilities for advancement, the directions along which he intends to try to move, and in which of these directions he is likely to be most successful. Finally, he must explore the line of action he must take to do the best for himself whatever his decision may be.

Broadly, the engineering apprentice has before him three possible lines of action, namely : (1) To fit himself to be a craftsman and remain as such ; (2) to train himself in such a way that he has a reasonable chance of entering the technical sides of industry as a technician, graduating later on to the managerial staff ; and (3) to follow that type of education which will fit him for employment in the design or research side of industry.

If his vision is confined to craftsmanship and ignores those outlets which lead off from such a training, then the ordinary evening class work is all that he needs. If, on the other ahand, he can see himself

---

The quotations given are from a paper on " The Functions of a Production Engineer " presented to the Institution by Mr. W. G. Groocock, member of Council, and published in *The Journal* of the Institution, Vol. XIV, No 4 The section on " Functions " is a précis of a part of the same paper.

fitting into the second category, then he needs something more. He wants a special kind of technical training—one which will fit him for what is to follow—but before he decides on this course he should ask himself—" Have I the necessary mentality to progress along the line on which I have set my heart ? "

The Production Mentality.

If you think of becoming a production engineer, the first question you should ask yourself is " Have I the production mentality ? "

The production mentality is characterised by a strong leaning towards the practical side of engineering, coupled with the ever present urge to more, and still more, production. Have you this leaning towards the practical side, and is it coupled with this urge ? If so, then your tendency is towards the production side as contrasted with the academical or more highly technical side. " The designing engineer thinks mainly in terms of machine performance, whilst the production engineer thinks in terms of time, price, and quality, having regard always to the equipment he has available for use . . . . The production engineer has existed under various definitions since the beginning of engineering, but owing to the need for specialisation we now have a type of engineer whose training and mentality fit him for the position of producing goods as distinct from that of designing them."

If you consider the above and apply it to your own case you have to ask yourself the question—" To which type do I belong ? " Is it to the reflective, analytical type, with a preference for the calm of the drawing office or the research department ? Or is it to the energetic, man-of-action type, to whom the whir of the machine shop is music and the natural routine of the establishment is a more or less perfect rhythm ? Can you, in your own estimation, be not only a technician but a manager, an organiser, a leader of men ? If so, you should train to be a production engineer.

The Functions of the Production Engineer.

The production engineer may be called by different titiles such as works manager, works superintendent, general machine shop foreman, according to particular local custom. His technique and methods will vary widely, according to the size and circumstances of his particular firm. Broadly speaking, however, his functions will be the same whether his firm be large or small, whether it be engaged on mass production, batch or job production.

As a typical instance, given the design of the product to be manufactured, with particulars of quantity, price, delivery dates, etc., the production engineer has to analyse the design, plan a series of operations to give the necessary quality of work, co-relate these operations to time, and keep the cost factor in line with requirements.

He has to see that his plant is laid out to best advantage and that "bottle-necks" are avoided. He has to decide when it is more economical to get parts made elsewhere, and when and what additional machinery is to be purchased.

No matter what the size of his firm, planning in one form or another is a necessity. It is for him to settle the sequence of operations, the jigs and tools required, and to arrange for the piecework rates or times for each operation. At all times he has to keep in the closest touch with the product design, inspection, costing and maintenance departments. Production has not only to be planned but controlled. It is now becoming common practice for the production engineer to control the purchase and delivery of material, and for stores and equipment to be in his charge. A major function of the production engineer is the control and handling of personnel. Success or failure will largely depend on his ability in this respect.

In small organisations one man may have to carry out most, if not all, of the functions outlined above. In large organisations there will be varying degrees of specialisation, the functions being divided up among many officials—from works managers, production managers, production engineers and their assistants to superintendents, planning engineers, ratefixers, jig and tool designers, and others.

Graduating from the Works.

Once they have graduated from the works on completion of apprenticeship and technical education, and have started (via such positions as chargehand, foreman, ratefixer, jig and tool designer, etc.) to climb the ladder of professional advancement, they all come under the general heading of production engineers, as that term is interpreted by the Institution.

Prospects and Emoluments.

It is difficult to refer in other than general terms to the financial rewards open to those who take up production engineering. So much depends on ability and experience, but there is always room at the top. In larger organisations four-figure salaries are not uncommon. At the best of times, however, engineering is not a highly paid job. It has to face too much competition (and too heavy a load of "overheads" proceeding in great measure from the ratio of capital to turnover) to be that. It can, however, be said with confidence that production engineering offers far more openings at considerably better salaries than any other branch of engineering, with the possible exception of the highly skilled sales side. It is easy to see why this should be so. Many educational institutions still concentrate on the more academic courses. Such training should, of course, turn out good technicians, good designers, but not necessarily good

practical workshop engineers and organisers. Industry will, of necessity, pay more to men who combine skilled workshop knowledge with managerial and organising ability than to men who are technicians only.

But do not decide to take up production engineering rather than the designing side simply because the prospects of pay appear to be better; they are only better for those who have the all-important production mentality. Unless you have that you are unlikely to rise much beyond the status of craftsman.

How to become a Production Engineer.

Given the production mentality and reasonable ability and ambition, a good training in the works as an apprentice, or otherwise, is a necessity. When, later on, you occupy an executive position you should be able to tell a workman how and in what time a job is to be done. Obviously, too, it is a great advantage if you can yourself demonstrate the time possibility of any job you may be handling.

During your years in the works, technical education has to be acquired, and there must be no shirking of this side of your training. For craftsmanship there are such courses as that of the City and Guilds of London Institute for machinists', turners', and fitters' work. These go farther than their title and touch upon certain of the activities of the production engineer. Students who have begun their studies in these courses may by transfer to other classes and by extended study cover the required ground. But to prepare for the wider field of production engineering more exacting preliminary training is desirable. A few colleges provide courses which from the beginning have as their objective the full training of the production engineer. Failing such courses, the best plan at present available is to take as a foundation of your technical training the National Certificate course, either in mechanical or electrical engineering, up to the attainment (usually at the end of three years) of the Ordinary National Certificate. You should then devote the next two years to special courses in Production Engineering designed to qualify you for the graduateship examination of this Institution. You can enter for that examination without limitation as to age and without any obligation to apply for membership of the Institution.

A primary duty of the Institution is to see that adequate facilities on the right lines are provided for the education of the production engineer of the future. In performing that duty the Institution has the invaluable assistance of many leading educationists such as Dr. Schofield, Dr. Anderson, Dr. Fisher, Mr. Griffiths, and Mr. Parsonage, principals respectively of Loughborough College, Birmingham, Wolverhampton, Wandsworth, and Chesterfield Technical Colleges. All of those named are members of the Joint Examination Board of the Institution.

How the Institution can Help You.

Should you wish to consider production engineering as your future career, you can have, on application, a copy of the Rules and Syllabus of the Graduateship Examination. If you decide to study for this examination, you can register with the Institution as a student, in which case steps will be taken to keep in touch with you up to the time of taking the examination, both directly and through members of the Institution, who will be kept informed of those registered as students. Members will also be recommended to give students advice and information, if desired, and will be entitled to invite registered students to occasional lecture meetings likely to be of special interest to them. Further particulars can be obtained on application to the Institution of Production Engineers, British Industries House, Marble Arch, London, W.1. Telephone: Mayfair 8080.